

UUVs in Battlespace Dominance



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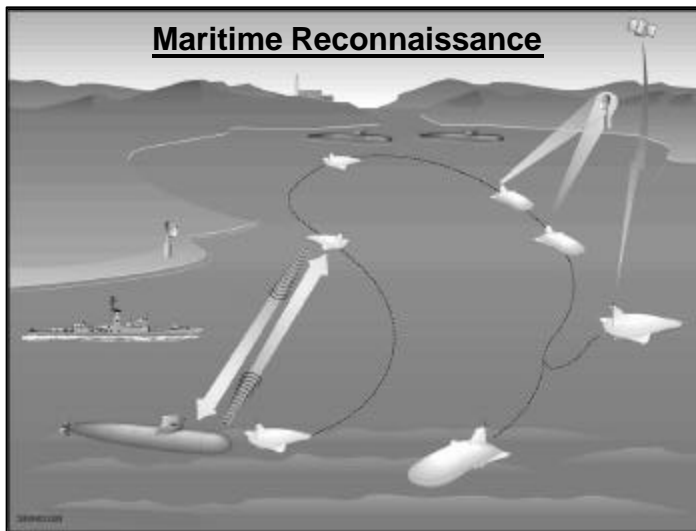
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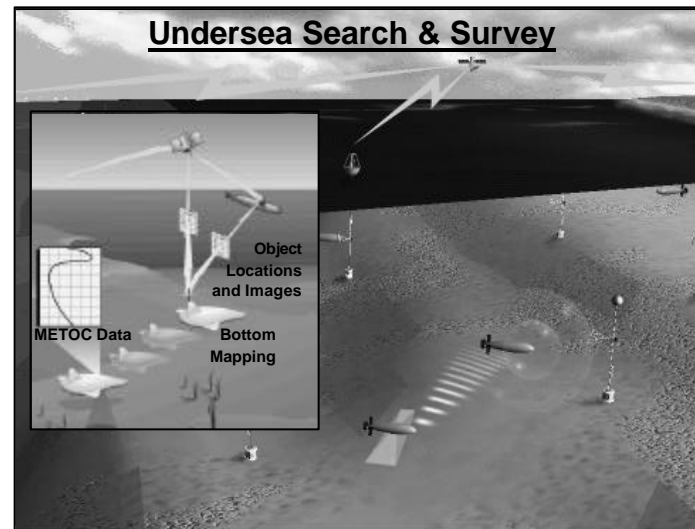


Some Key Applications

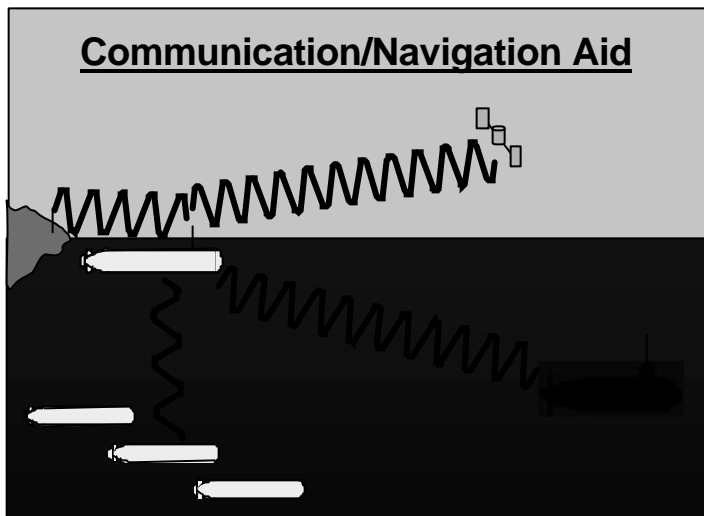
Maritime Reconnaissance



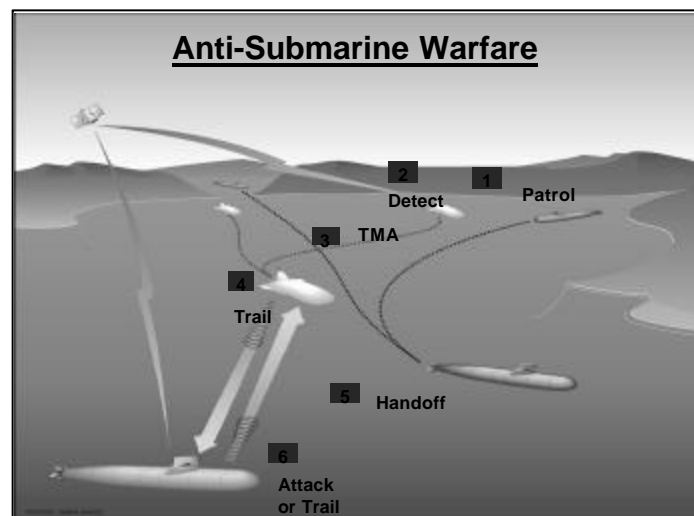
Undersea Search & Survey



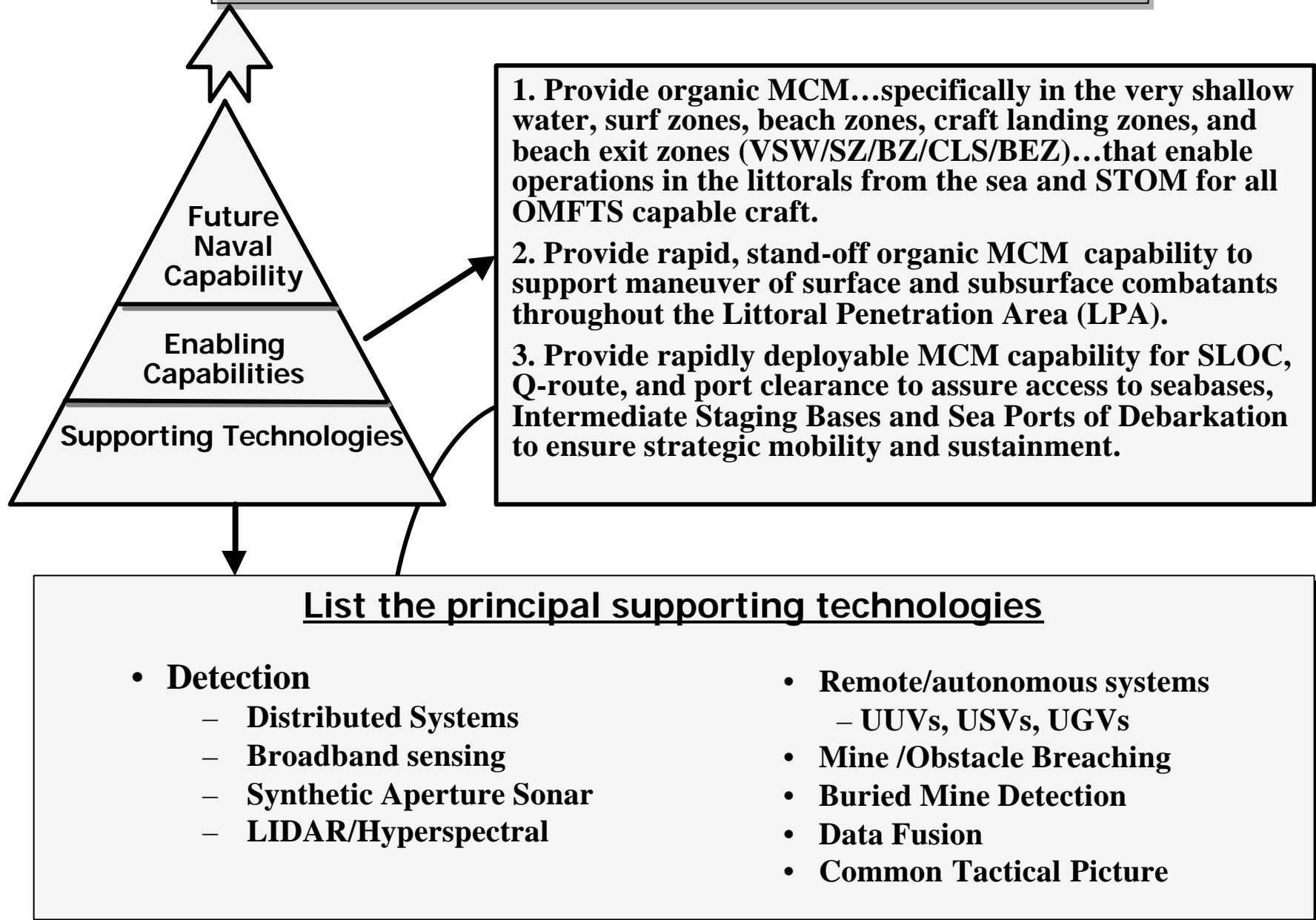
Communication/Navigation Aid



Anti-Submarine Warfare



Organic Mine Countermeasures

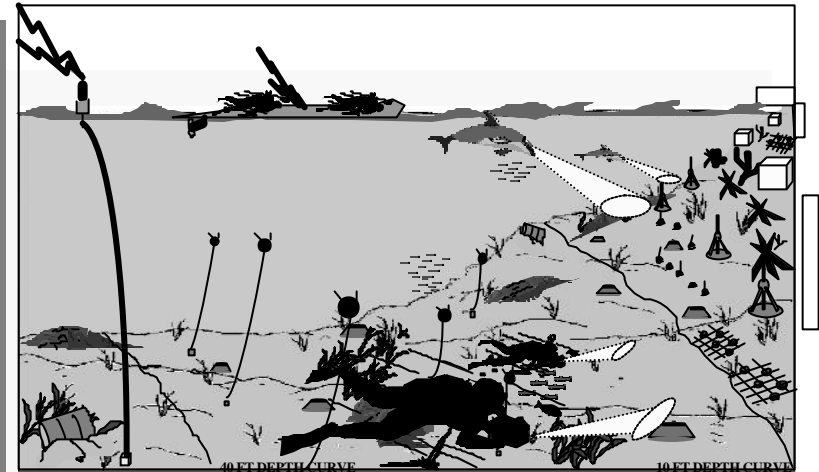




Clandestine Reconnaissance *Capability Objective*

- Rapid Clandestine Very Shallow Water / Surf Zone Minefield and Obstacle Reconnaissance

- Increase Margins of Safety for Diver
- Reduce Tactical Timelines
 - From Slow, Diver-Centered Operations to Multi-Tasked, UUV-Centered Area Operations
- Enables Maneuver Space Critical to STOM
 - From Narrow Linear Lanes
 - To Tactical Flexibility Along the Coast

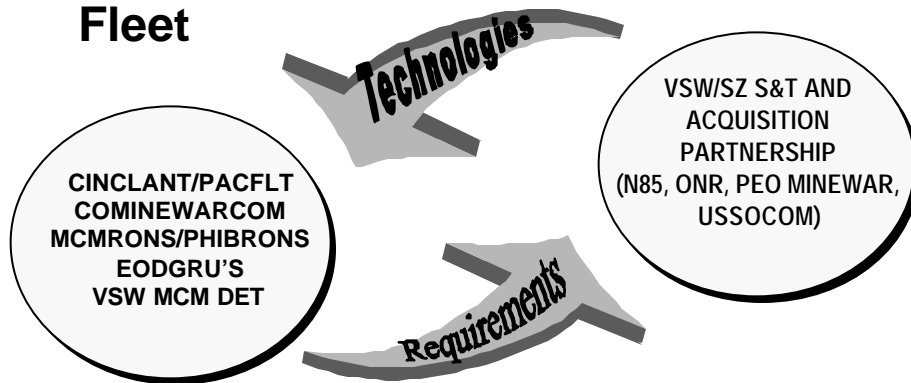




Ocean Engineering & Marine Systems

System Development Strategy

- **Connectivity Between R&D / Acquisition Communities and the Fleet**



- **Develop/Demonstrate Critical Component Technologies**

- Navigation
- Communications
- Sensors
- Control
- Employ Mature Platforms

- **Interact with User**

- Show User
- Learn from User

- **Refine Concept of Operations**

- **Refine Notional System**

- **Demo Critical Elements of Ops**

- Fleet Battle Experiments

- **Enable Low-Risk Smart Acquisition**

- **Notional System Description**

- Easily Deployable, Low Cost Platforms
- Recon, Reacquisition, Inspection, Marking

- **Notional CONOPS**

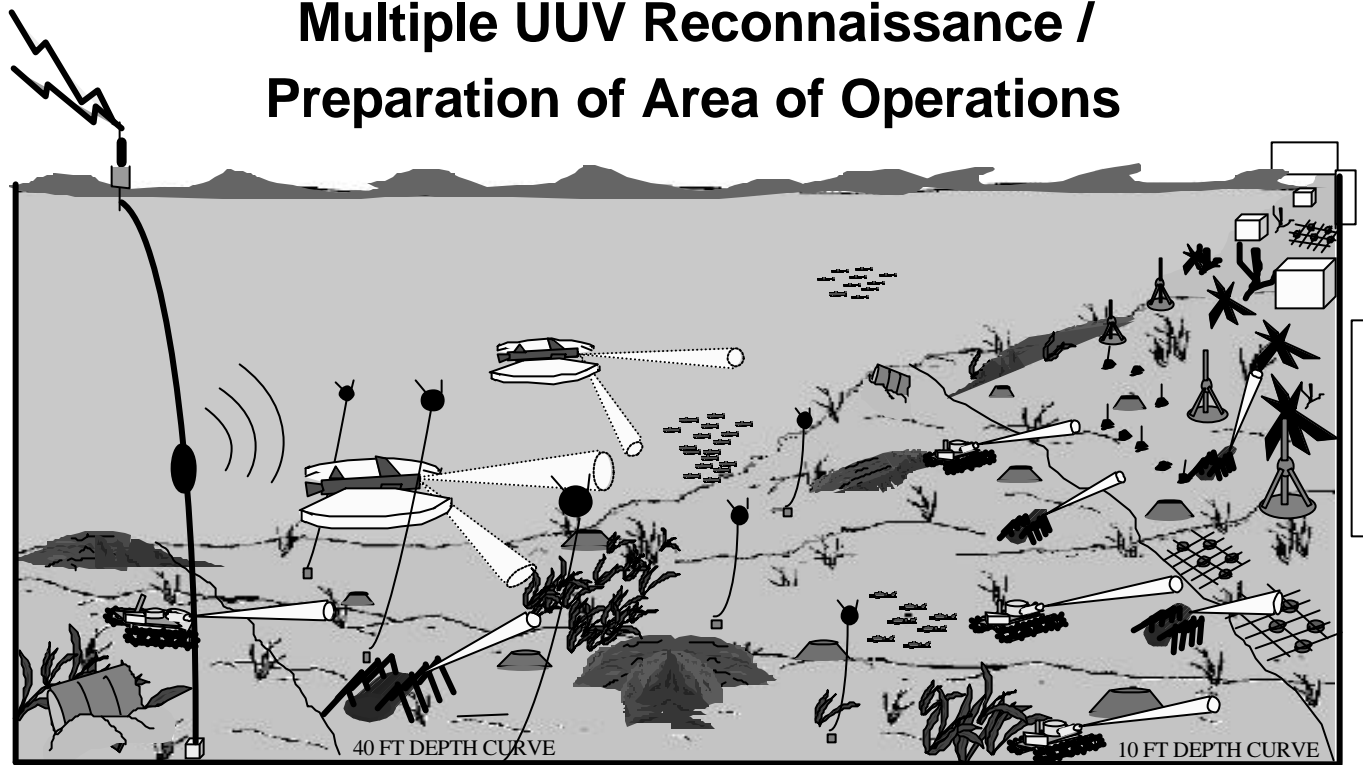
- Wide Area Recon
- Lane Recon
- Lane Clearance



Ocean Engineering & Marine Systems Capability Demonstrations



Multiple UUV Reconnaissance / Preparation of Area of Operations



KEY ELEMENTS OF DEMONSTRATIONS

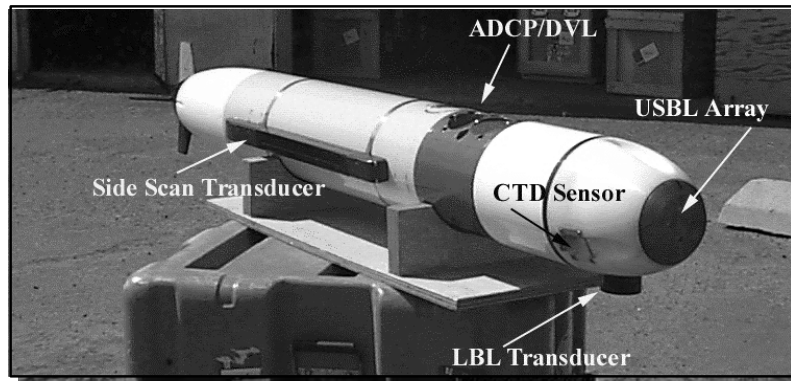
- AUV Deployed Transponders
- Area Reconnaissance
- Data Relay to Command
- CAD / CAC Processing, Area of Ops Visualization, Computer-Aided Lane ID
- Command Redirection
- Reacquisition and Inspection of Targets
- Placement of Target Markers and/or Neutralization Devices
- Placement of Lane Markers
- Command Actuation





Ocean Engineering & Marine Systems

Test Bed & Demonstration Platforms



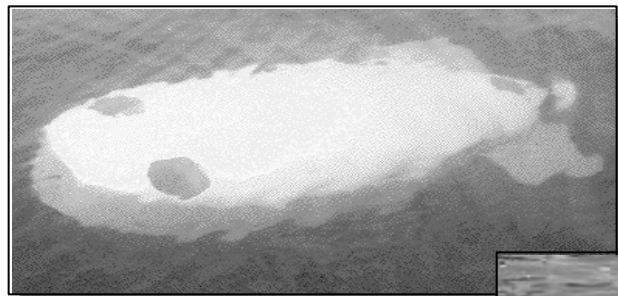
REMUS / WHOI

- Miniaturized DVL
- Multi-vehicle COMMS / NAV System
- Payload Delivery
- CAD / CAC (CSS, LM, Raytheon)
- Optical Imaging



Lemming / FMI / CSS

- PEIC
- Tactile Sensors
- CCD
- Sidescan Sonar (Marine Sonics)

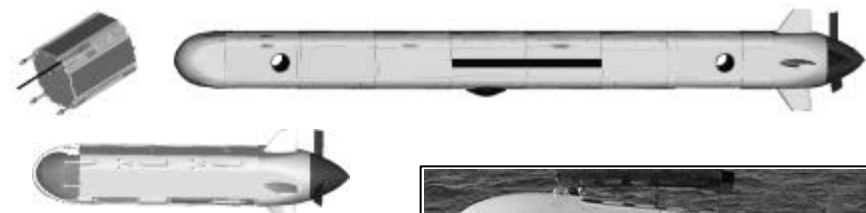


CETUS / LM Perry

- Advanced FLS
- Low Light Video Imaging
- REMUS Reacquisition Package
- CETUS II



CETUS II



Morpheus



OEX

Modular AUV / FAU

- Multi-Vehicle Interoperability
- Mine Hunting Strategies
- 100 / 390 and 1200 KHz Side Scan Sonars
- Extensive / Modular Sensor Packages



SAHRV in Action



Operations within Kelp

Chemical Sensing
in the Marine Environment





Millennium Challenge 2000



★ ***JFCOM/J9 Experimentation Directorate***

★ ***Dates: August - September 2000***

★ ***"Collection of Experiments"***

- *U.S. Army, JCF XXI*
- *U.S Air Force, JEFX 00*
- ***USN, FBE-H***
- *USMC, Millennium Dragon*

★ ***Geographically Dispersed Locations***

a
y
hile
ascagoula
Island
eans



FBE-HOTEL



★ ***Objective:*** *Demonstrate emerging MCM technologies with **emphasis on UUVs***

★ ***Concept:*** *Sailors and Marines :*

-employ technologies, interpret products, provide feedback

ONR POs and PI s:

-provide tech assist, collect & analyze data, continue S&T

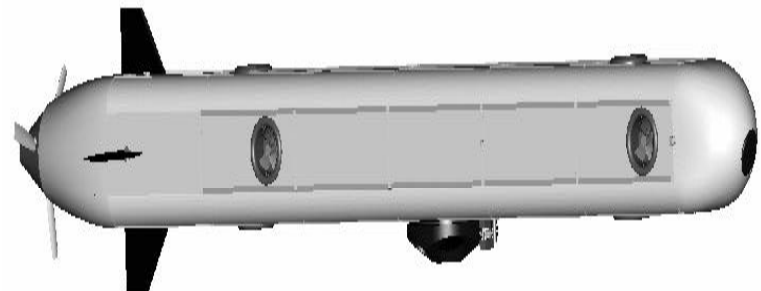


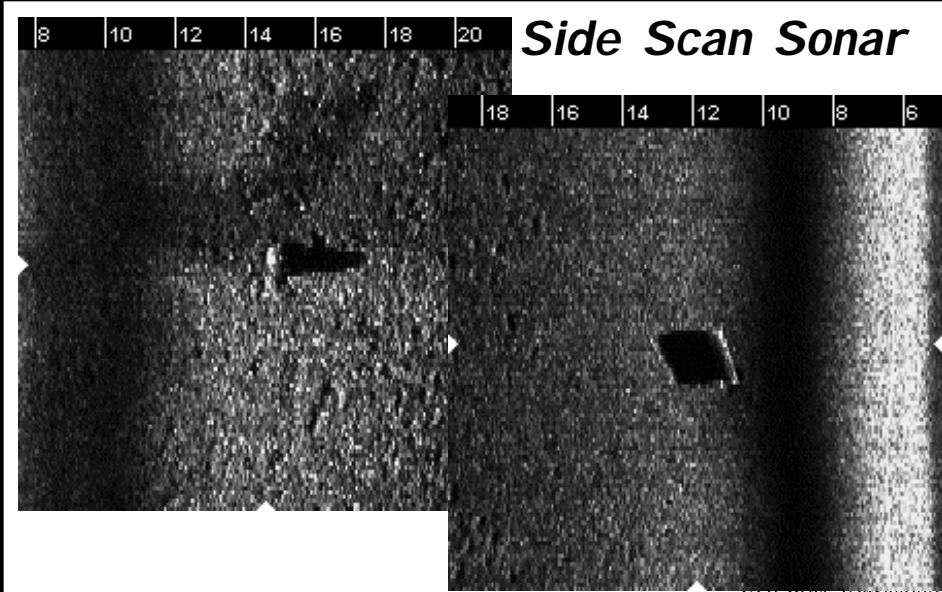
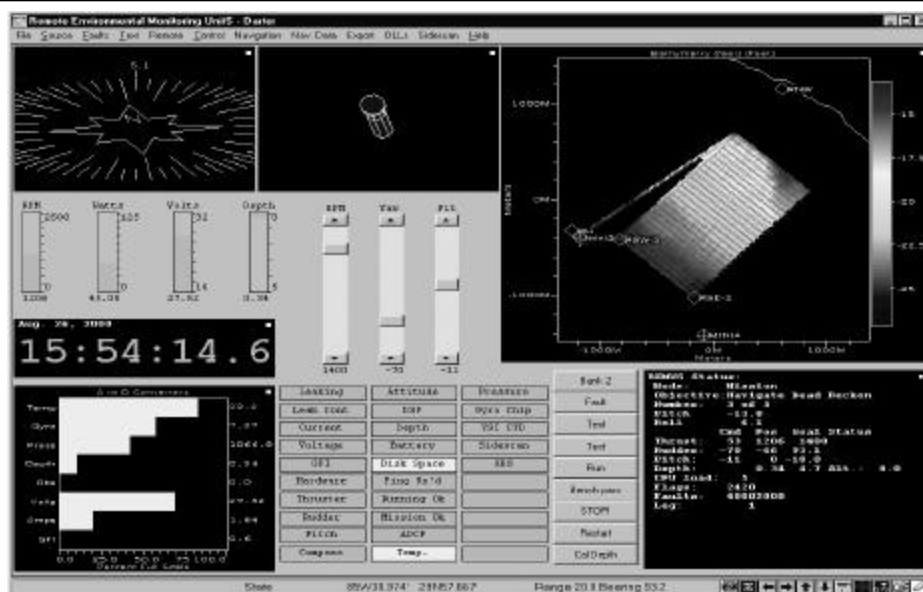
VSW Mine Hunting

★ ***REMUS/SAHRV***

★ ***CETUS II***

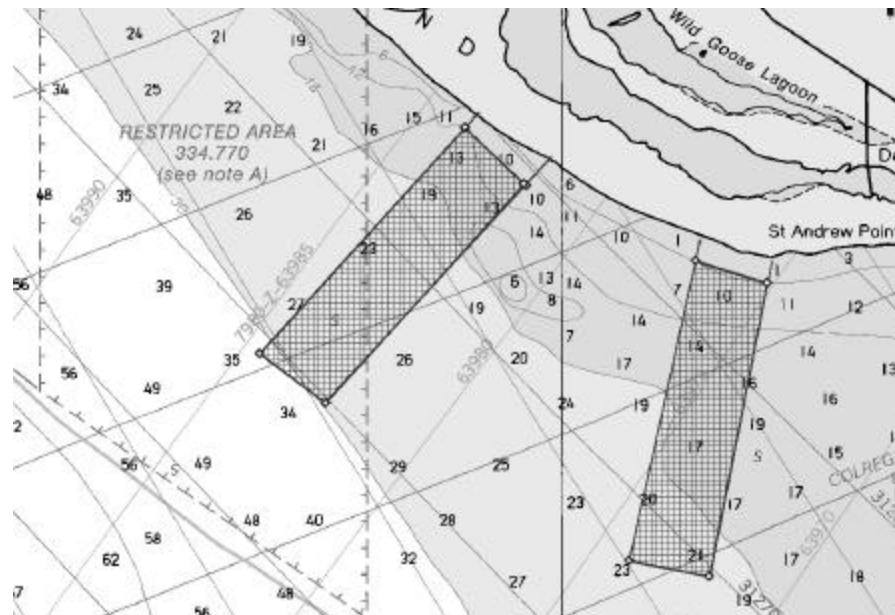
★ ***MORPHEUS***







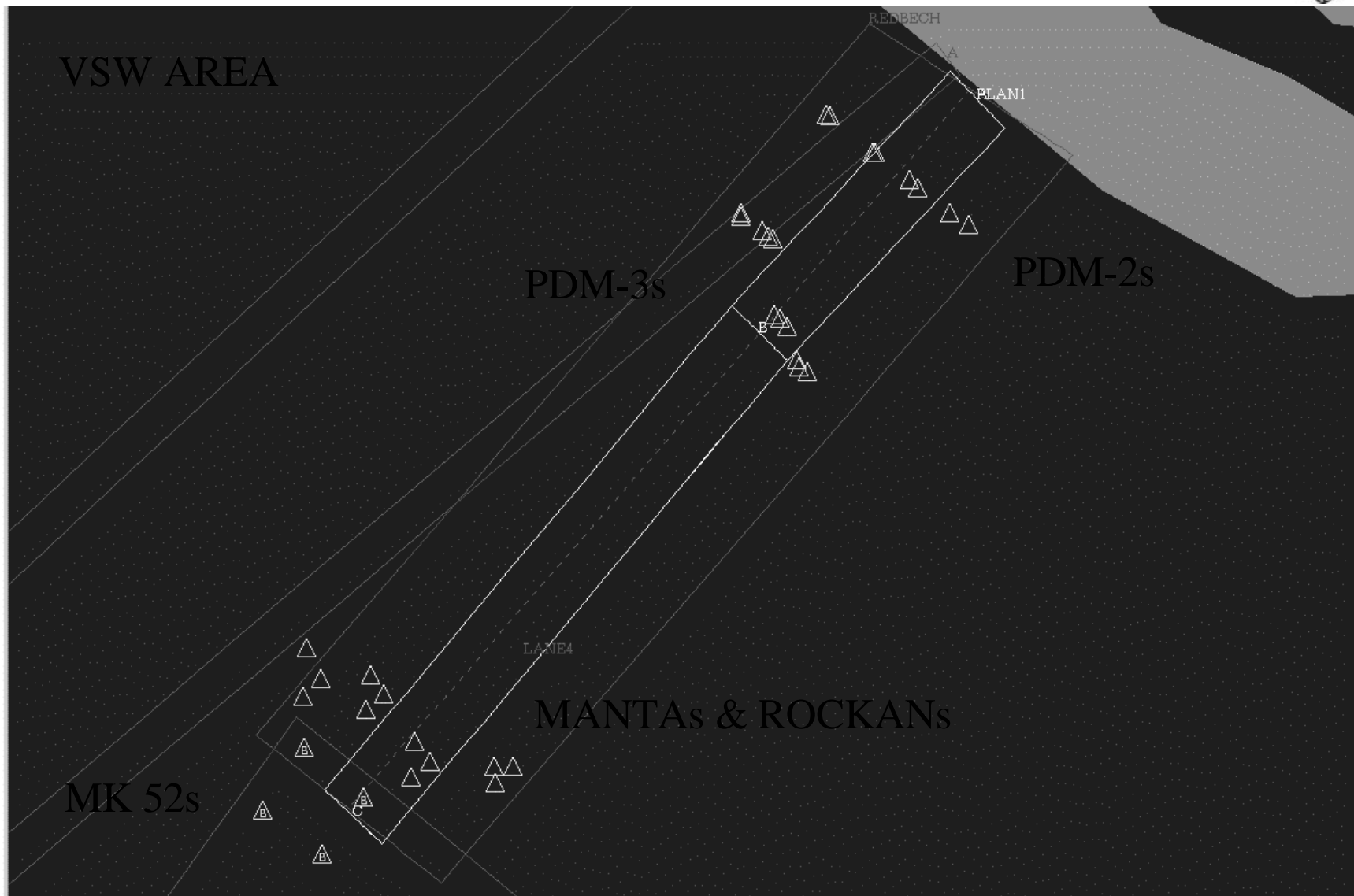
RED Beach Survey



- **3400 Meter by 900 meter area (563 football fields)**
- **3 Nights, 125 Kilometers, 65 nautical miles**
- **100 percent bottom coverage**
- **Data processed and turned over to MEDAL within hours of recovery**

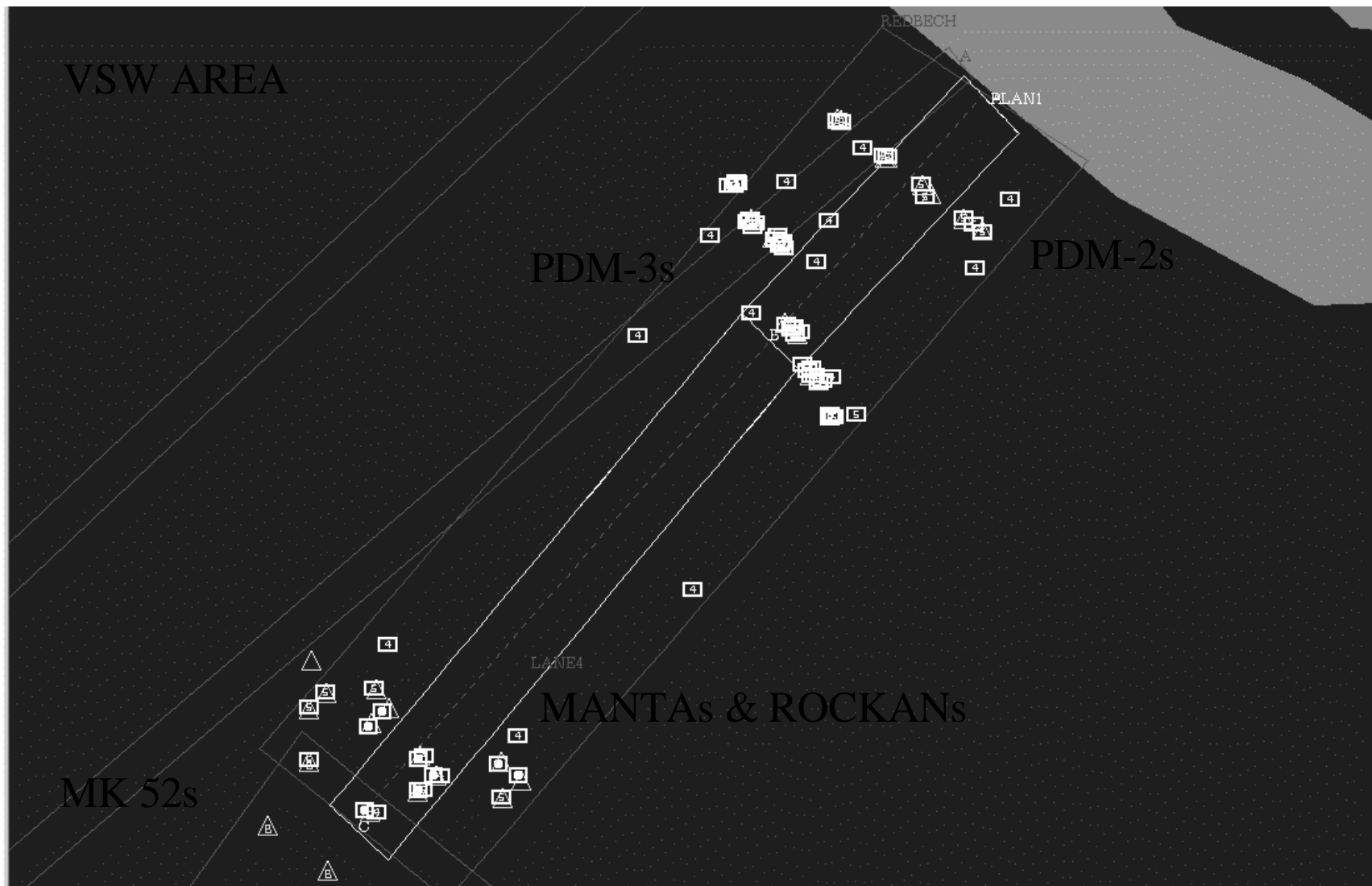


VSW Ground Truth



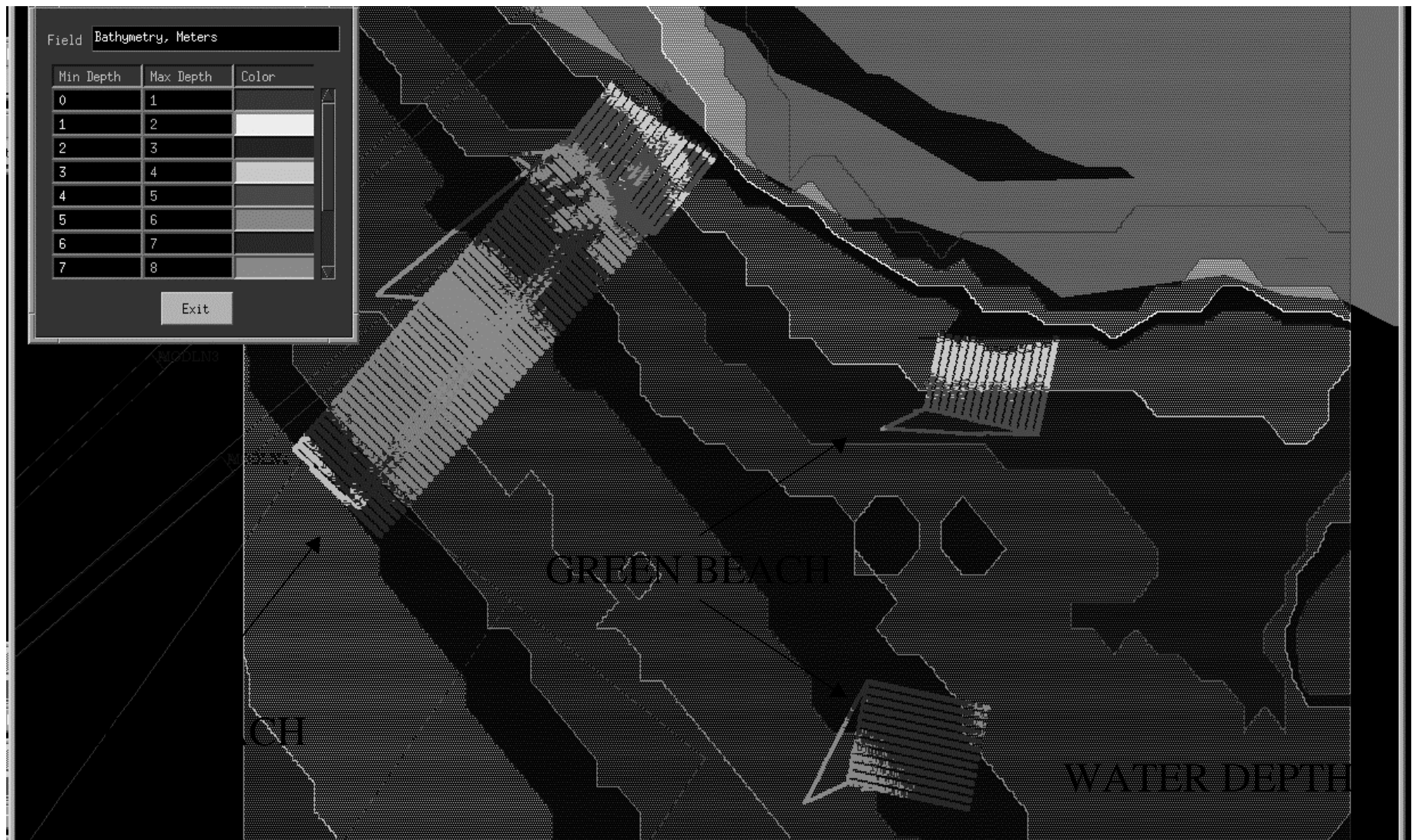


REMUS & Ground Truth





SAHRV vs NAVO





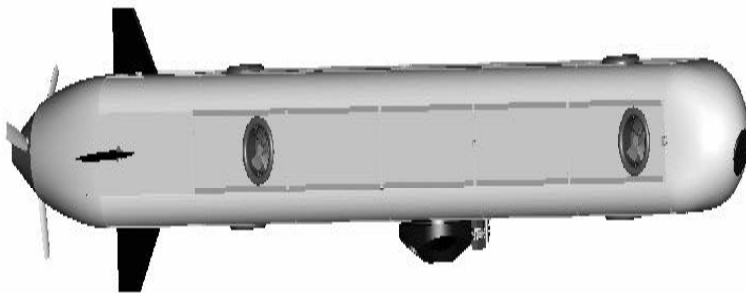
SAHRV/REMUS



- ★ ***Employed by NAVSPECWARCOM and MCM VSW Det.***
- ★ ***Conducted hydrographic recon and mine hunting in VSW***
 - *51 CRN'S; $P_c=97\%$ (with a low P_{fa})*
 - *32 hours on task (8 missions)*
 - *2 Sq. NM coverage area (2 beaches)*
- ★ ***Estimate six 2-man diver teams 48+ nights to minehunt the same area***

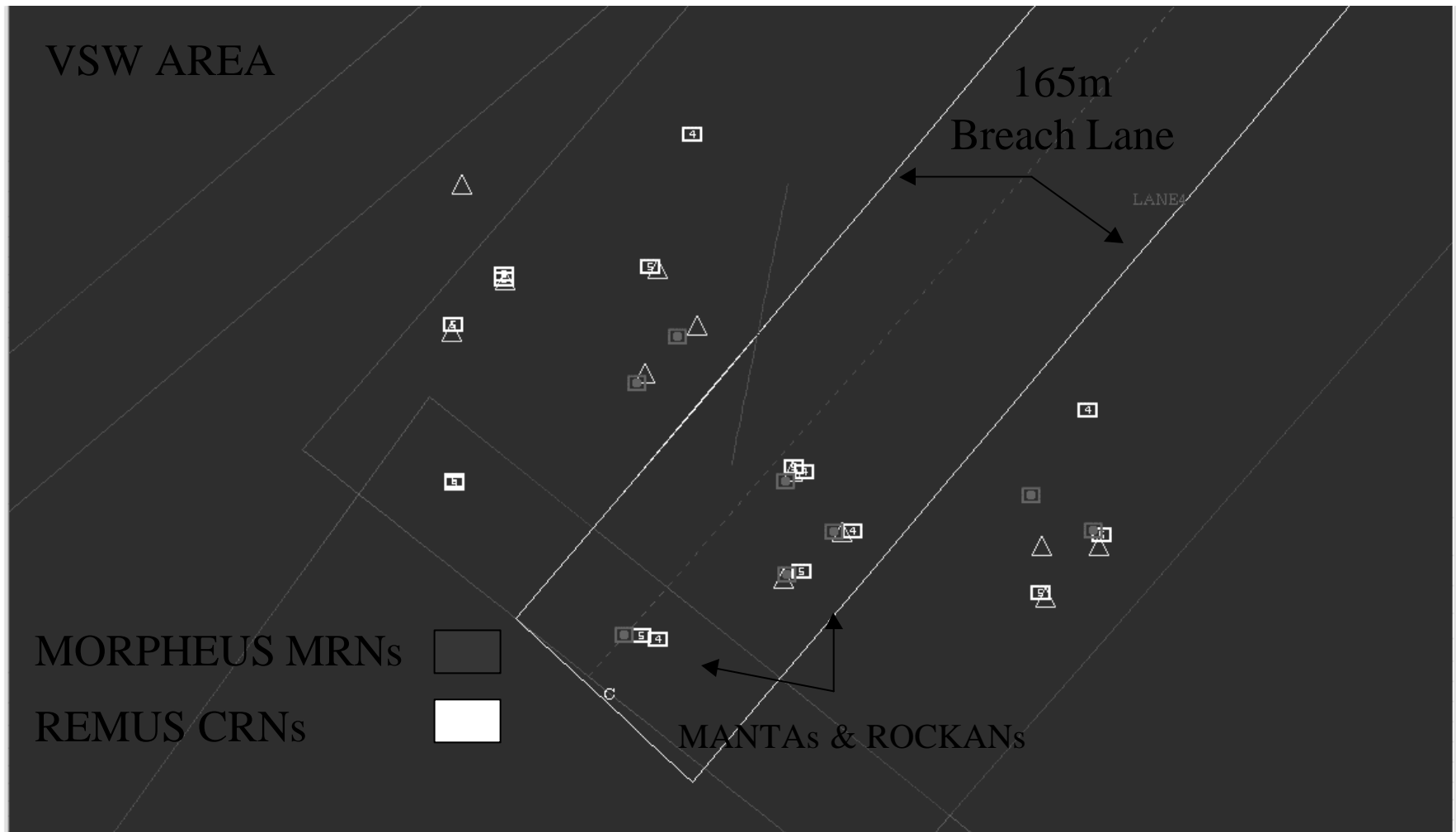


MORPHEUS





REMUS, MORPHEUS & Ground Truth





MORPHEUS

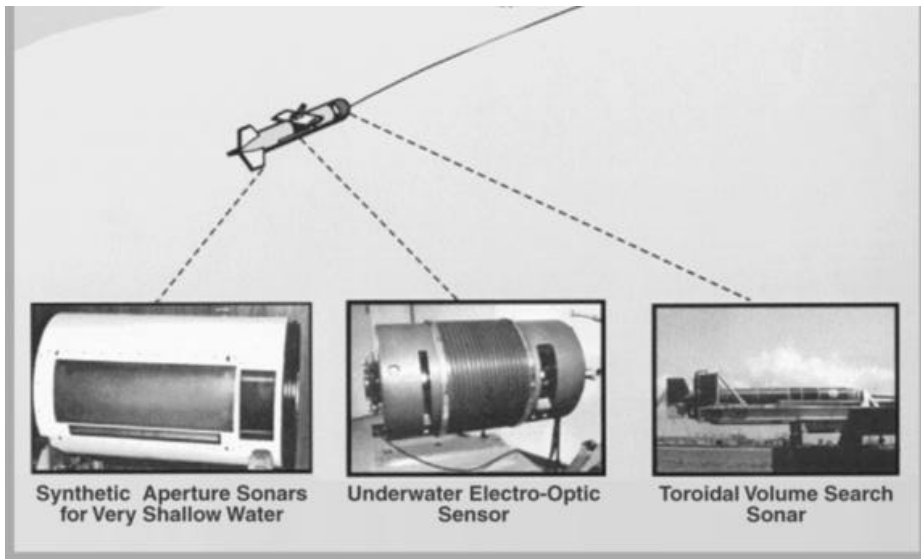


- ★ ***Reacquired and ID'd (video) 10 mines and 2 NOMBOs in the VSW and SW zones.***
- ★ ***First time an AUV reacquired and ID'd an AUV acquired MLO.***
- ★ ***PMA by USN EOD yields MRN' designation.***
- ★ ***Video image snippets entered in CTP via MEDAL.***
- ★ ***5 missions: VSW through 75'.***



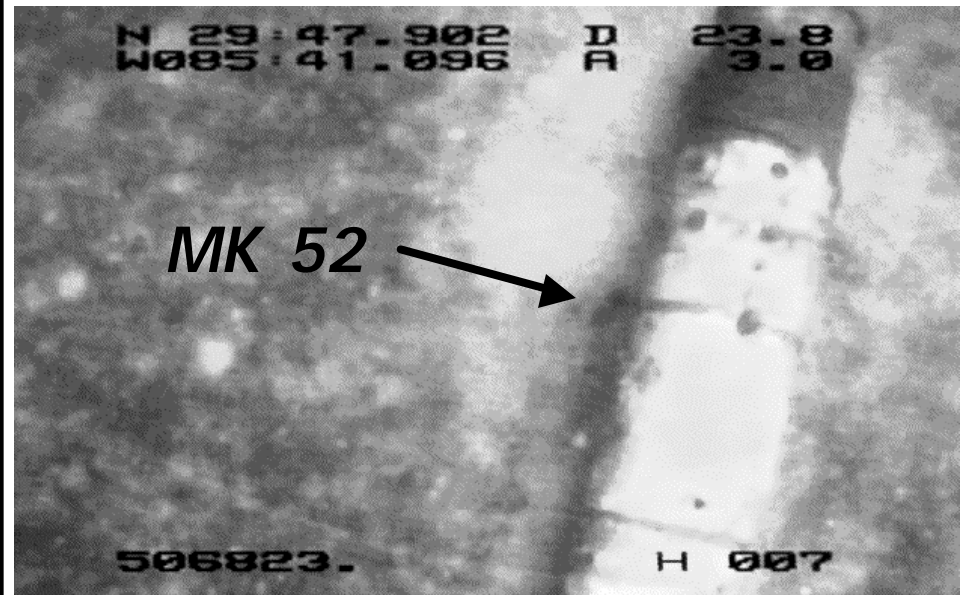
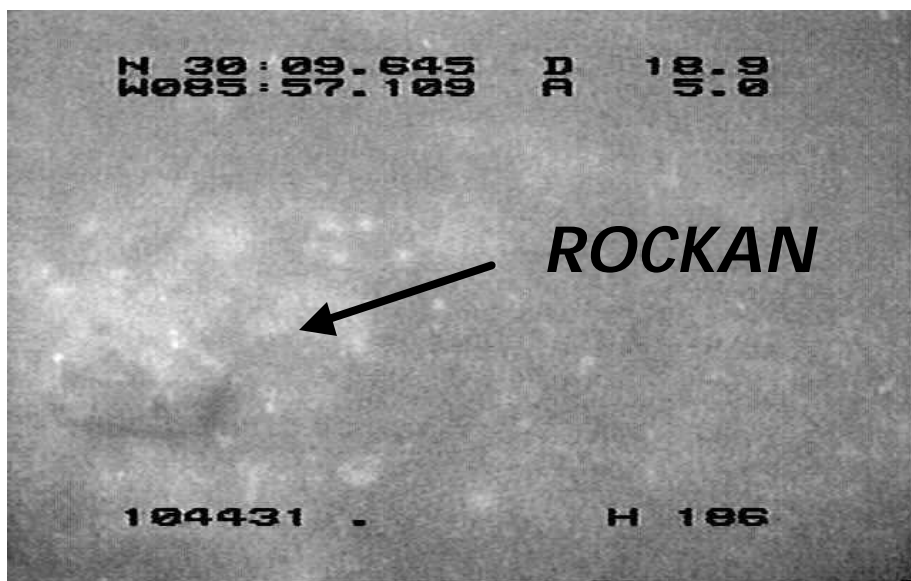
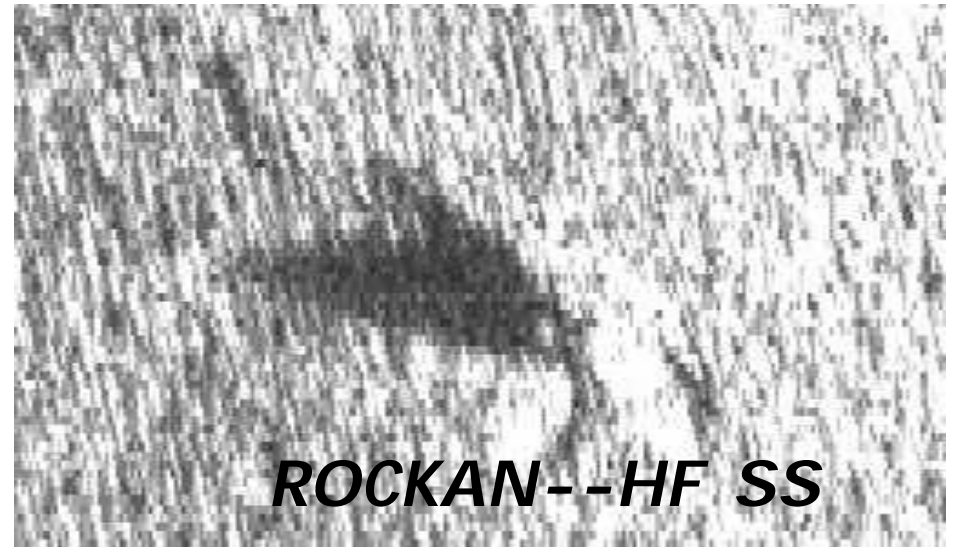
Deep/SW Mine Hunting

- ★ *Battlefield Planning AUV (BPAUV)*
- ★ *A/S--TVSS & SAS/EOID*
- ★ *OCEAN EXPLORER*





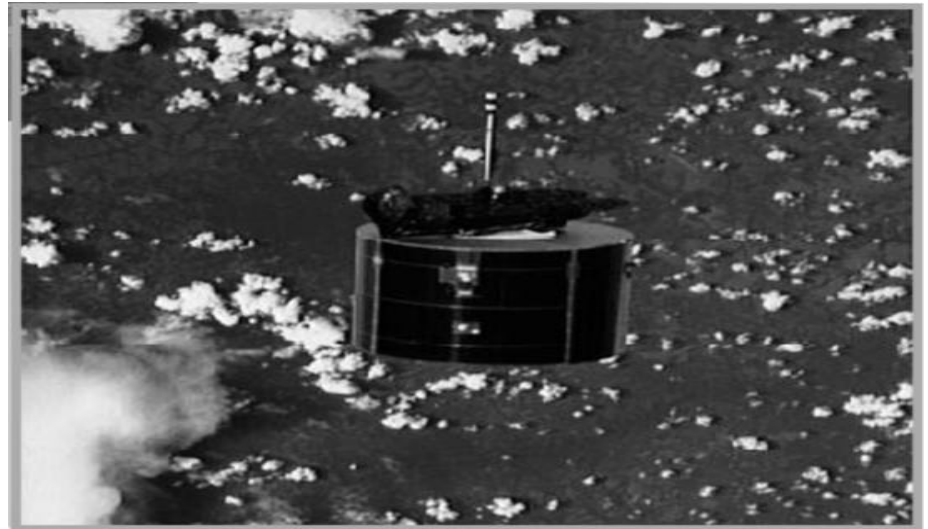
OCEAN EXPLORER





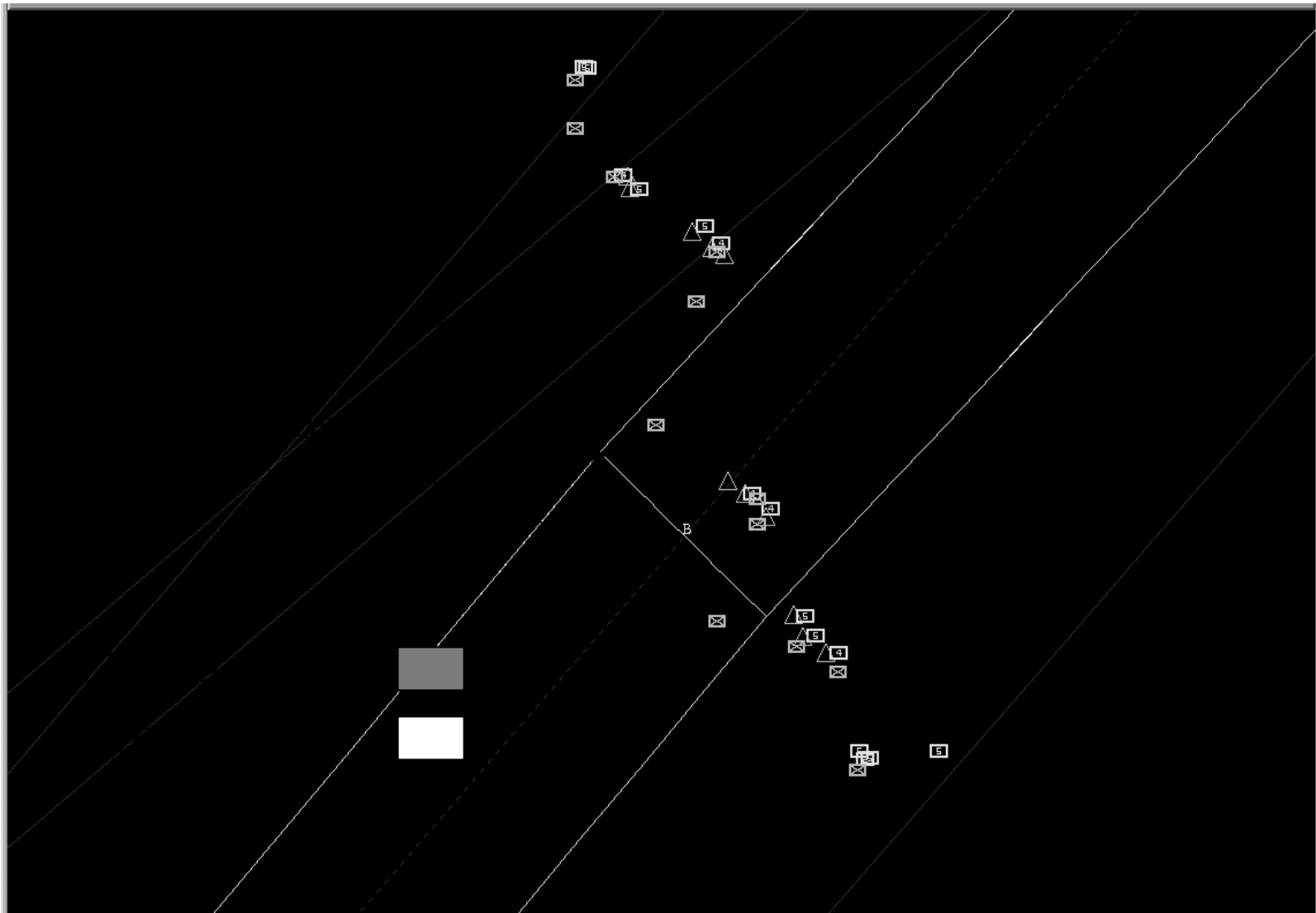
Surveillance & Reconnaissance

- ★ ***Littoral Remote Sensing (LRS)***
- ★ ***Airborne Remote Optical Spotlighting System (AROSS)***
- ★ ***Littoral Airborne Sensor-Hyperspectral (LASH)***



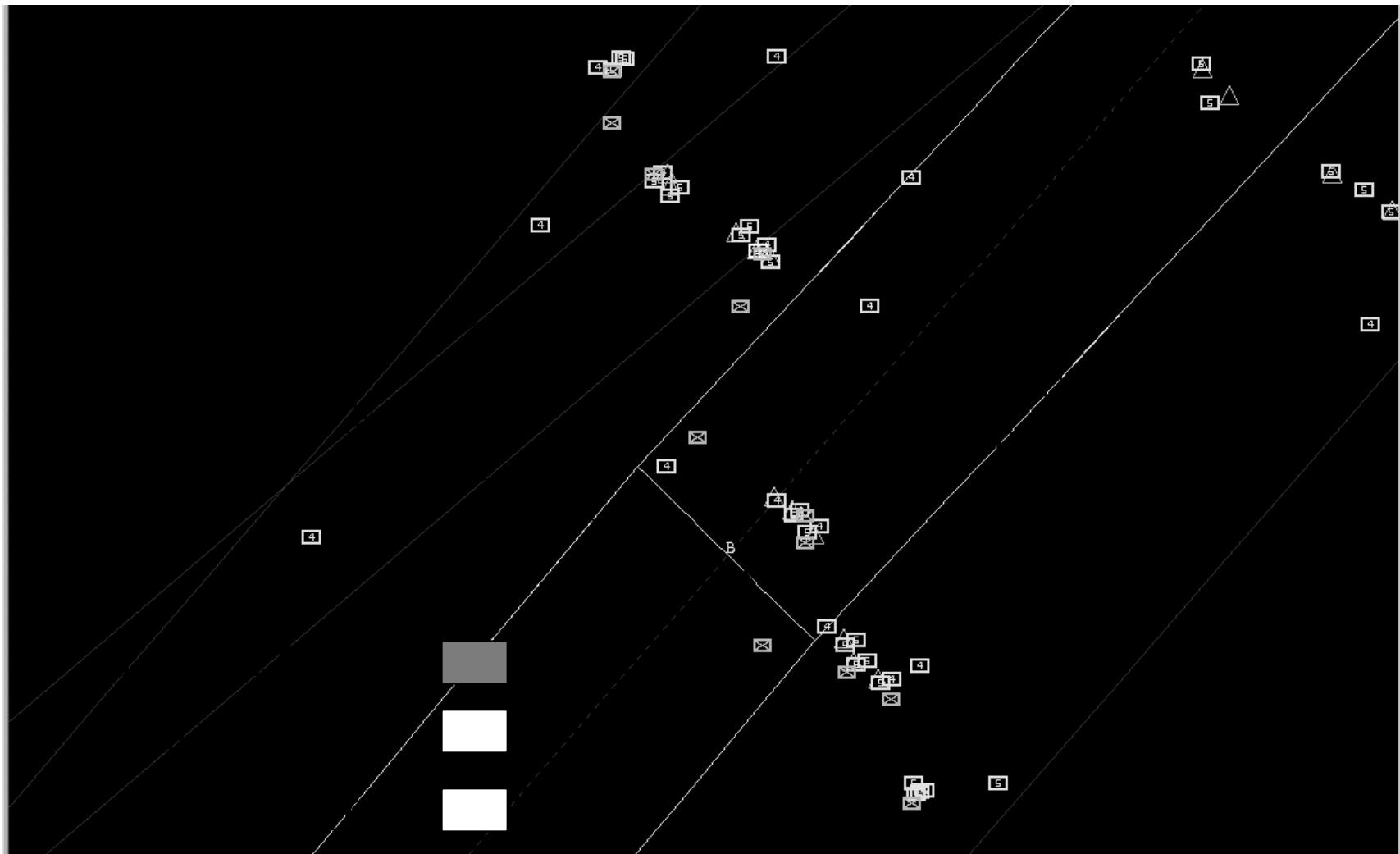


Ground Truth -- *LRS & AROSS*





Ground Truth -- *LRS/AROSS/REMUS*





Bottom Line

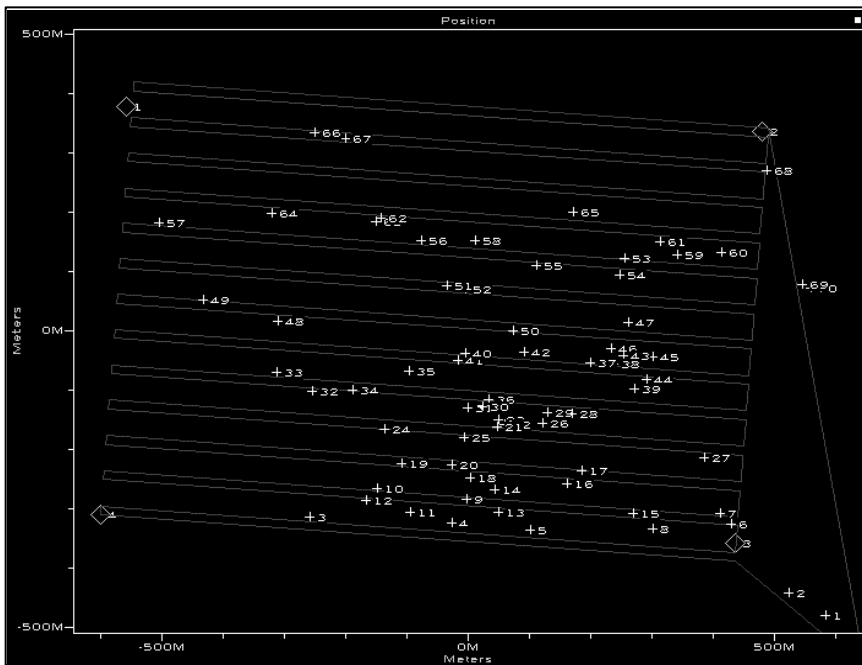


- ★ ***UUVs: Demonstrated the capability to “reduce the tactical timeline & get the diver/mammal out of the minefield”***
 - *Significant battlespace coverage*
 - *“Speedy” mission completion; timely info feedback*
 - *Accurate*
 - *LRS, AROSS & UUV data fusion led to 100% ID of PDM-3s*
- ★ ***Favorable demonstration conditions***
 - *low sea state*
 - *A1 Bottom*
 - *Good acoustic conditions*



VSW/SZ MCM Program

Effects of Coral Bottom on Mine Detection



- Very Difficult Bottom for MCM Operations - Bottom Type B3
- Large False Contact Rate
- 74 Contacts Called
- 14 Actual Targets in Area

CAD / CAC

SAHRV Field Evaluation II Sep 98

562 sonar images, 80 mines (area = 670m by 670m)

STANDALONE CAD / CAC RESULTS

| Algorithm | PdPc | False Alarms Per Image |
|-----------|----------------|------------------------|
| CSS | 93.8 (75 / 80) | 0.365 (205 / 562) |
| RAY | 90.0 (72 / 80) | 1.240 (697 / 562) |
| LMC | 96.3 (77 / 80) | 2.039 (1146 / 562) |

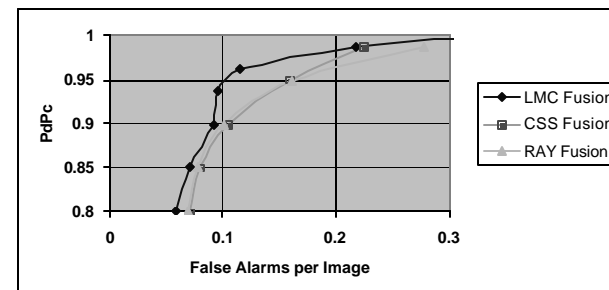
FUSION OF CSS, RAY, & LMC CAD / CAC OUTPUTS

| False Alarms in 562 Images | | | |
|----------------------------|---------|---------|---------|
| PdPc (%) | CSS (1) | RAY (2) | LMC (3) |
| 98.8 (79 / 80) | 126 | 156 | 123 |
| 95.0 (76 / 80) | 90 | 91 | 60 |
| 90.0 (72 / 80) | 59 | 57 | 52 |
| 85.0 (68 / 80) | 45 | 44 | 40 |
| 80.0 (64 / 80) | 40 | 39 | 33 |

(1) CSS Fusion: METHOD BASED ON MAXIMIZING FISHER RATIO

(2) RAY Fusion: OPTIMIZED THREE-TEAM OR-ING

(3) LMC Fusion: ORTHOGONAL LLRT





OEX AUV - 13 June 00 - Manta AA002

Acoustically Transmitted Image





Ocean Engineering and Marine Systems

1st Generation Small MCM UUVs: Acquisition



PMS - EOD Acquisition

NOTIONAL S-C-M SYSTEM (1ST GEN)

4 SWIMMERS
2 NAV SETS
1 C2/TDA SYSTEM
SUPPORT EQUIPMENT

NOTIONAL R-I-N SYSTEM (1ST GEN)

6 VEHICLES
2 NAV SETS
1 C2/TDA SYSTEM
SUPPORT EQUIPMENT

| QUANTITIES | 00 | 01 | 02 | 03 | 04 | 05 | TOTAL |
|------------|-----|-----|----|----|----|----|-------|
| VSW MCM | AOA | | | | 2* | 6 | S-C-M |
| DET | | AOA | | | | 1* | R-I-N |
| BG/ARG EOD | | | | | | 0 | S-C-M |
| DETs | | | | | | 1* | R-I-N |

PMS - 325J (USSOCOM) SAHRV Acquisition: IOC 02





UUVs for Battlespace Dominance

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